representations, and is an interesting example of the manner in which the theory of electricity and magnetism is treated on the continent.

It is assumed that electric phenomena are due to motion of some sort going on in every volume element of the ether, and the displacement produced by this motion is represented by a vector called the "tonic vector." Quadratic functions of the time differentials of the components of this vector are then assumed for the kinetic energy and the rate of conversion of electrical energy into heat, while the potential of the forces which resist the tonic motion is assumed to be a quadratic function of the curls of the same vector. The application of Hamilton's principle at once gives the equations of motion of the ether, and these, by a slight modification, become identical with Maxwell's equations. This modification is described by the author as a change in the system of units, but it is really a change in the system of quantities discussed.

In nearly all works on electricity this subject of units is treated in such a way that it presents a serious stumbling-block to the student. He is, for instance, almost led by the phraseology to suppose that quantities of electricity in the electrostatic and electromagnetic systems are quantities of precisely the same nature, just as are a pound and a gramme of water, for example; but that, being regarded from different points of view, they have somehow different dimensions in terms of the fundamental units; and not infrequently, by an exercise of faith rather than of reason, he believes this. A quantity of water may be measured either by its mass or by its volume, and, loosely speaking, either result is the measure of the quantity of water. But, speaking accurately, we cannot measure the quantity of water; we can measure certain properties of that quantity, of which one is the mass and another and different property is the volume. In a precisely similar manner electricity measured by the electrostatic system is one property of the electricity, and electricity measured by the electromagnetic system is another property; either may be arbitrarily defined as the quantity of the electricity, but it is inconsistent and misleading to describe both properties by the same name.

The concrete representation suggested as an interpretation of the Maxwellian equations is modelled on the theory of von Helmholtz, and is characterised by three main features. The first of these is the familiar conception of two incompressible fluids, the positive and negative *real* electricities; in a dielectric the real electricity is supposed to be bound, so that it cannot move out of the volume element in which it exists; but in a conducting medium it is capable of moving, and does so with a velocity proportional to the force acting on it. It is then found that, in the electrostatic state, the force acting on the real electricity is such as would be due to a certain distribution throughout space of a substance which repels the real electricity according to the law of the inverse square. An arbitrary multiple of the density of this supposed substance is defined as the density of the *free* electricity, and this constitutes the second main feature of the concrete representation. To bring about some simple relation between these two sorts of electricity the third main feature is introduced, namely the conception of electric polarisation; it is supposed that the real electricity within any volume element is capable of moving in such a way under the influence of electromotive force that positive electricity appears at one end of the element and negative at the other; thus there arises a density of electricity due to electric polarisation, and the definitions are such that at any point the density of the free electricity proves to be equal to the sum of the densities of the real electricity and of that due to polarisation.

Round these three conceptions are gathered several subsidiary definitions and suppositions, the mathematical reasoning being intricate and detailed; the whole constitutes a scheme of considerable complexity, of which indeed it is difficult to form a clear conception; as a physical theory, it would of course be extremely unnatural, but as a mere illustrative analogy it is instructive.

After considering Maxwell's equations of action at a distance, Dr. Curry shows by what assumptions and what modifications of the concrete representation we may pass from them to von Helmholtz's scheme; and he then considers the independent derivation of the latter from empirical laws.

There is an interesting chapter on the theory of the Hertzian oscillations, founded on Hertz's own memoir, but with the analysis given in greater detail. Other chapters deal with cyclic motions and illustrative mechanisms, with longitudinal ether oscillations, and with the theory of electric and magnetic striction.

The work is, on the whole, characterised by a clear style, though several serious difficulties are ignored, and some of the main features in the reasoning are not emphasised as their importance deserves. Thus in the transition from Maxwell's to von Helmholtz's equations the reader is left in considerable doubt as to whether certain of the suggested modifications are purely arbitrary assumptions corresponding to radical changes in the concrete representation, or merely a presenting of the old differential equations in a slightly altered form. There are also some serious errors which greatly disfigure the book, though fortunately they do not invalidate the leading argument. Thus on page 33 we are offered two different schemes of the dimensions of the quantities of the electrostatic system in terms of the fundamental units, a result due to a confusion of angular momentum with density of angular momentum. The kinematics on page 10 are faulty; and on page 23 we find the dissipation function spoken of as an energy function, and actually treated as such in the application of Hamilton's principle.

J. G. L.

OUR BOOK SHELF.

Reform of Chemical and Physical Calculations. By C. J. T. Hanssen, C.E. Pp. xvi + 72. (London: E. and F. N. Spon, Ltd., 1897.)

THE book deals specially with calculations of specific and latent heat, and heat of combustion of various substances. In the preface the author states that all his deductions are based upon the natural laws of atomic combination, heating, expansion and compression of aeriform substances, upon a few of the best substantiated experiments, and upon the fact, discovered by the author, that, near the 41° of latitude, the specific gravity of

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oxygen gas of atmospheric density, at the temperature of freezing water, is exactly 1/700 of the gravity of distilled water, at its temperature of greatest density. He advocates this as an international circle of latitude for all gravitational calculations. The author says that "from this fact as a starting point, all fundamental values have been determined, and expressed with *absolute exactness* in units and vulgar fractions instead of approximately by rows of decimals," and he claims that his arithmetical method gives an "absolute accuracy of results, and a facility of manipulation not attainable by any other known method."

It is possible that the use of convenient vulgar fractions for physical constants may conduce to facility of arithmetical manipulation, but the author, for the sake of his vulgar fractions, makes assumptions which can surely not conduce to the absolute accuracy which he claims. For example, he takes 17/12 as the ratio between the specific heats of gases at constant pressure and at constant volume, because 17/12 is a simple fraction *not far* removed from the determined value of the ratio for simple gases, and, moreover, in spite of experimental evidence to the contrary he uses the same ratio in the case of such gases as CO_2. The author also advocates, and uses, a new scale of temperatures, not very different from the absolute Centigrade scale, to facilitate his arithmetical work. This he calls the normal scale.

The author makes a great number of calculations, arranging the results in tables. Where experimental evidence is at variance with any of these results he considers the experiments are inaccurate. The arithmetical work is conducted with considerable ingenuity, though occasionally the mode of statement of details is not unexceptionable, *e.g.* (on p. 24), $\log 0{\cdot}00000 - \log 0{\cdot}21249 = \log \bar{1}{\cdot}78751 = 0{\cdot}61307$.

Prof. G. Karsten, of Kiel, has written an introduction to the book, in which he calls special attention to the author's proposal (mentioned above) that all observations and calculations on gravity should be referred to one common international circle of latitude, to be called the *circle of international gravity*. He also mentions § 80 and Table xxiii. as samples of the satisfactory results of the author's calculations and observations on heat produced by combustion, and recommends the book to the attention of scientific men.

The book on the whole, though the calculations are, in many parts, of considerable and varied interest, does not seem to justify its ambitious title.

Citizen Bird: Scenes from Bird-life in plain English for Beginners. By Mabel Osgood Wright and Elliot Coues. Pp. xiv + 430. (New York: The Macmillan Company. London: Macmillan and Co., Ltd., 1897.)

THIS book consists of a series of pleasant dialogues between Dr. Roy Hunter and some children, at Orchard Farm in New England, in which the children learn the appearance and habits of a great number of the birds around them. It has been rather unfairly compared in a daily paper to "Sandford and Merton." It must be allowed that the didactic dialogue is apt to be tiresome, and in this case the children are of course a little unnatural in their acuteness and their ardent desire to learn. English boys would probably learn better from a sound and scholarly handbook: one in whose hands I to-day placed Sir Humphry Davy's "Salmonia," after a few days' trout-fishing, not unjustly complained that Halieutes and his pupils always caught exactly the fish they wanted—which was not the case when he was fishing. It may perhaps be doubted whether the experiment would answer on this side the water.

But the familiar names of Dr. Coues and Miss M. A. Wright are a more than sufficient guarantee of the excellence of the ornithological part of the book, and to English students of bird-life it will be of real value. Here we have the actual every-day life of the birds most familiar to the New Englander, which very few of us can hope ever to study in their own homes. Many of them, of course, closely resemble our own, and a very few are identical with ours. But the great majority are new to us, and of these we learn very pleasantly from this book something that we could not have picked up except by crossing the Atlantic ourselves. The photographic illustrations are excellent; and there is a useful index and a classification of North American birds. But perhaps the best thing in the book is the account given by Mammy Bun, the negress, of the mocking-bird as she knew it in the Southern States.

W. WARDE FOWLER.

LETTER TO THE EDITOR.

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The Worsted Test for Colour Vision.

IN NATURE of September 23 reference is made to the death of Dr. A. F. Holmgren, professor of physiology in Upsala University: "His attention," it is said, "was in the early seventies directed to colour-blindness, and in 1878, he published his well-known work on colour-blindness in relation to railways and the Navy, thus bringing to a practical issue the work long before begun by George Wilson, of Edinburgh (1855). This led him to the invention of his now well-known worsted test for colour vision."

May I be allowed to say that Prof. George Wilson, of Edinburgh (my brother) was, during a long series of investigations as to the nature and extent of this peculiarity of vision, constantly in the habit of using the "worsted test." In his work, "Researches on Colour Blindness" (published in 1855 by Messrs. Sutherland and Knox, Edinburgh, and Simpkin, Marshall, and Co., London), references very frequently occur to the use of wools as a colour test. On page 25 he says, "Dr. Y., aged 27, when requested to match coloured worsteds by daylight placed the full reds and greens together, but when the same skeins were placed before him by gaslight, he picked out the greens and placed them apart."

At page 44, while examining artillery soldiers at Leith Fort, he put into the hands of one man a bundle of coloured wools, from which he was to make a selection. The soldier was nervous, but retained with firm grasp a yellow skein of wool, putting it in the bundle containing red purple and red brown, with manifest perplexity at all the colours being alike. Page 40, soldiers in the Edinburgh garrison, known by previous experiments to be colour-blind, were closely watched while *from a heap of coloured wools* each one was asked to select first the red skeins and then the green, no notice being taken of the selection made till eight or nine skeins were set aside as red and the same number as green.

At page 70, 437 soldiers were asked to assort coloured papers, *wools*, and pieces of glass, and to place those of the same hue together. At page 77 a young Kaffir gentleman, whose knowledge of English was limited, was asked to match *Berlin wools* and tinted papers.

One advantage gained by making wools the test, was that many of the colour-blind have a specially keen sense of minute details, so that in seeing the same object more than once, they would recognise it by some small point or wrinkle or crease, scarcely perceptible to an ordinary observer. In the wool test this power was of no service to them.

I think from the examples quoted (and many more might be given), priority in making use of the "worsted test" may fairly be claimed for Prof. George Wilson. At many of the lectures given by him on this subject a diagram was exhibited, consisting of a square of calico to which were attached specimens of wools as selected by the colour-blind tested by him. In the course of time the colours faded, so as to lessen its value, and it was put aside.

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